5.0 EBR SAMPLING AND ANALYSIS

EBR baseline and performance monitoring will be conducted to provide data for evaluation of EBR progress as detailed in this section and Appendix H. Prior to the transition from SEE to EBR at the site, steam injection will be discontinued and there will be a period of extraction only. During this phase, routine sampling locations and frequencies will remain as established in the RD/RAWP. Following the SEE phase at the site, monitoring of EBR operations will include a combination of process monitoring (e.g., pressures, flow rates) and analytical monitoring for TEA distribution, microbial activity, and dissolved concentrations of site COCs to evaluate the progression of EBR. This section discusses the performance monitoring specific to the EBR implementation. Table 5-1 summarizes the monitoring, sampling, and analysis methods and frequencies. Sampling programs are further discussed in the following subsections. Additional detail for EBR sampling and analysis is included in the QAPP/SAP for EBR implementation (included as Appendix H).

Table 5-1 EBR Monitoring, Sampling, and Analysis Methods and Frequencies

Media	Locations	Monitoring/ Analysis	Frequency	Sample Purpose	Additional Information in QAPP/SAP
Baseline					
Liquid	• Select SIWs and MPE wells (as listed in Table 4-2). • All newly installed injection and extraction wells (as listed in Table 4-1)	• VOCs (8260B) • SVOCs (8270) • ICP Metals (6010C) • Nitrate and Sulfate (9056A) • Alkalinity (SM 2320B) • Sulfate field screening	• Single event near the end of post-steam extraction activities (existing wells) • At least one week after well development (new wells)	• Performance (Baseline) • Operational Strategy Assessment (adjustments to TEA injection/ extraction strategy)	Yes
Soil	• All drilled locations (drilled using sonic)	• Continuous logging • PID readings	• Approximate 10-foot vertical core intervals or where changes are noted.	• Operational Strategy Assessment (injection/ extraction strategy)	No
		• LNAPL Dye Test Kits	• At core intervals of suspected LNAPL based on odor, staining, or PID readings	• Operational Strategy Assessment (injection/ extraction strategy)	No
		• VOCs (EPA 8260B) • TPH (8015B)	• 1 per 10 ft interval where dye test kit is positive	• Operational Strategy Assessment (confirmation of qualitative monitoring/ analysis)	Yes

Table 5-1 EBR Monitoring, Sampling, and Analysis Methods and Frequencies

Media	Locations	Monitoring/ Analysis	Frequency	Sample Purpose	Additional Information in QAPP/SAP
Injection Well and Injection Solution Sampling					
Liquid	• TEA Injection fluid	• ICP Metals (6010C) • Sulfate (9056A)	• Monthly	• Operational Strategy (verification of TEA concentration)	Yes
Liquid	• New and existing injection locations (24) (as listed in Tables 4-1 and 4-2)	• VOCs (8260B) • ICP Metals (6010C) • Sulfate and Nitrate (9056A)	• Quarterly	• Performance (dissolved VOCs reduction, TEA solution distribution, dissolved metals monitoring)	Yes
Extraction Well Sampling					
Liquid	• New and existing extraction locations (24) (as listed in Tables 4-1 and 4-2 except sampling frequency is higher for wells in next row)[2]	• VOCs (8260B)	• Quarterly	• Performance (dissolved COCs reduction) • Operational Strategy Assessment (bioactivity and TEA distribution)	Yes
		• TPH (8015B) • ICP Metals (6010C)	• Semiannual	• Performance • Compliance (trace metals monitoring)	Yes
		• Sulfate Field Screening • Sulfate (9056A)	• Biweekly during the first month (sulfate only), then transition to monthly thereafter with confirmatory offsite laboratory analysis (9056A) for every 10% of field screening samples • Monthly at extraction wells once extraction turned off • pH and temperature monitoring will stop following shutoff of extraction well	• Operational Strategy Assessment (TEA distribution)	Yes

Table 5-1 EBR Monitoring, Sampling, and Analysis Methods and Frequencies

Media	Locations	Monitoring/ Analysis	Frequency	Sample Purpose	Additional Information in QAPP/SAP
Liquid	Select extraction wells: • ST012-CZ18 • ST012-CZ19 • ST012-CZ21 • ST012-UWBZ31 • ST012-LSZ39	• Sulfate Field Screening • Sulfate (9056A)	• Weekly during the first two months, then transition to monthly thereafter with confirmatory offsite laboratory analysis for every 10% of field screening samples	• Operational Strategy Assessment (TEA distribution)	Yes
Groundwater Monitoring Well Sampling					
Liquid	Groundwater monitoring wells[2]: • ST012-C02 • ST012-U02 • ST012-W12 • ST012-U37 • ST012-RB-3A • ST012-W24 • ST012-U38 • ST012-W38 • ST012-U12 • ST012-CZ02 • ST012-CZ06 • ST012-CZ07 • ST012-CZ11 • ST012-CZ20 • ST012-UWBZ05 • ST012-UWBZ11 • ST012-UWBZ14 • ST012-UWBZ16 • ST012-UWBZ24 • ST012-LSZ03 • ST012-LSZ06 • ST012-LSZ08 • ST012-LSZ10 • ST012-LSZ15 • ST012-LSZ19 • ST012-LSZ22 • ST012-LSZ25 • ST012-LSZ42	• VOCs (8260B) • ICP Metals (6010C) • Sulfate (9056A)	• Quarterly	• Performance (dissolved COCs reduction) • Operational Strategy Assessment (TEA distribution)	Yes

Table 5-1 EBR Monitoring, Sampling, and Analysis Methods and Frequencies

Media	Locations	Monitoring/ Analysis	Frequency	Sample Purpose	Additional Information in QAPP/SAP
Liquid	• Select monitoring wells: • ST012-CZ02 • ST012-CZ20 • ST012-UWBZ24 • ST012-UWBZ31 • ST012-LSZ10 • ST012-LSZ42	• PLFA and DIC (SIP) • SRB (qPCR)	• It is estimated that analysis is likely to occur between six and twelve months following the initiation of sulfate injections based on field conditions (including sulfate travel time and groundwater temperatures). Once initial microbial analysis is conducted, future sampling will be conducted based on evidence of SRB and biodegradation.	• Performance (SRB population, evidence of biodegradation) • Operation Strategy Assessment (TEA distribution)	Yes
Liquid	• Annual Groundwater Monitoring Locations (see AMEC, 2013 with modified locations per Table 5-3 of the RD/RAWP)	• See AMEC, 2013 with modified locations per Table 5-3 of the RD/RAWP.	• Annual	• Compliance (RODA 2)	No
Process Water Sampling					
Liquid	• Treatment System Influent	• VOCs (8260B)	• Monthly	• Performance (mass removal)	Yes
Liquid	• GAC Influent • GAC Midfluent • GAC Effluent	• VOCs (8260B)[1]	• Weekly for influent and midfluent until influent concentrations stabilize, then monthly, quarterly at effluent	• Performance (mass removal by GAC) • Operation (breakthrough at Midfluent) • Compliance (effluent discharge permit)	Yes
		• SVOCs (8270)[1]	• Monthly[1]		
		• Pesticides/PCBs (8081/8082)[1] • HRGC/HRMS (1699)	• 8081/8082 Monthly with a second sample sent for HRGC/HRMS analysis if there are any detections of prohibited compounds[1]		

Table 5-1 EBR Monitoring, Sampling, and Analysis Methods and Frequencies

Media	Locations	Monitoring/ Analysis	Frequency	Sample Purpose	Additional Information in QAPP/SAP
	• Effluent Discharge	• Liquid Discharge Flow Rate	• Daily flow meter readings[1]	• Compliance (effluent discharge permit)	No

Notes:

[1] May be modified based on final discharge permit.

[2] Water quality parameters (pH, temperature, DO, and ORP) will be evaluated at each sampled well using a flow through cell and calibrated probes.

ASTM – American Society for Testing Materials
DIC – dissolved inorganic carbon
DO – dissolved oxygen
FID – flame ionization detector
GAC – granular activated carbon
GC – gas chromatograph
HRGC/HRMS – high resolution gas chromatography/ high resolution mass spectrometry
LNAPL – light non-aqueous phase liquid
LSZ – lower saturated zone
MPE – multiphase extraction
ORP – oxidation reduction potential
PCBs – polychlorinated biphenyls
PID – photoionization detector
PLC – programmable logic controller
PLFA – phospholipid fatty acids
qPCR – qualitative polymerase chain reaction
SEE – steam enhanced extraction
SVOCs- semi-volatile organic compounds
SIP – stable isotope probing
SIW – steam injection well
SRB – sulfate reducing bacteria
TPH – total petroleum hydrocarbons
VOCs – volatile organic compounds

5.1 Baseline Sampling

Prior to EBR injection and extraction activities, sampling will be conducted to determine baseline conditions and to adjust operational strategy based on conditions in the field.

5.1.1 Pre-EBR Groundwater Sampling

During the final stages of SEE at the site, multi-phase extraction (MPE) wells will be sampled to determine baseline dissolved BTEX+N concentrations within the TTZ at the site. After drilling and well construction activities for new injection and extraction wells are complete, Amec Foster Wheeler will perform an initial round of groundwater sampling to document baseline conditions in the EBR treatment area prior to EBR activities. Results will be used to establish baseline concentrations of COCs/Chemicals of Potential Concern (COPCs) as established in the RODA 2. The following analyses by laboratory will be conducted at all newly installed wells and select MPE wells at the site:

- Sulfate (U.S. Environmental Protection Agency [EPA] Method 9056A)
- ICP Metals (EPA Method 6010C)
- VOCs (EPA Method 8260B)
- SVOCs (EPA Method 8270C)

Baseline sampling will also help evaluate potential adjustments to the injection/extraction strategy.

5.1.2 Soil Characterization for LNAPL

As discussed in Section 4.1.2, all new well cores will be screened with a PID for the presence of VOCs. Dye test kits will be used to confirm LNAPL presence/absence that is suspected based on visual and PID screening. The selection of a core interval for dye testing will be subject to the judgement of the field geologist and will depend on the uncertainty associated with the visual and PID screening methods. It is anticipated that the frequency of dye test kit use will decrease over the investigation period as confidence in visual and PID readings increases. Soil samples with positive dye test kit results will be sent off site for analysis of VOCs by EPA Method 8260B and TPH (sum of gasoline range organics and diesel range organics) by EPA Method 8015B. Results of LNAPL characterization will be used to make adjustments to screened intervals, well layout, and the TEA injection/extraction strategy.

5.2 Injection Well and Injection Solution Sampling

Sampling at individual existing and new injection wells and the injection solution will be used to monitor dissolved VOC concentrations, dissolved metal concentrations, and sulfate concentrations. Injection monitoring will help assess necessary changes to injection/extraction strategy.

5.2.1 TEA Injection Solution Sampling

On a monthly basis, TEA injection solution samples will be collected to confirm injection solution concentration. TEA injection solution will be analyzed on a monthly basis for dissolved metals concentrations via EPA Method 6010C to confirm quality assurance reports received from the TEA supplier regarding the arsenic concentration in TEA.

5.2.2 Injection Well Sampling

Each existing and new injection well will be sampled and analyzed for VOCs via EPA Method 8260B, dissolved metals vis EPA Method 6010C, and for sulfate and nitrate via EPA Method 9056A to monitor: TEA distribution, progress in reduction of dissolved VOCs, and any changes in dissolved metals within the formation that may have resulted from TEA solution injections.

5.3 Extraction Well Sampling

During EBR activities, each extraction well (24 wells total) will be sampled and analyzed for VOCs (BTEX+N) via EPA Method 8260B. BTEX+N monitoring at individual extraction wells will help document progress towards the transition to monitoring.

On a semiannual basis, all 24 extraction wells will be sampled and analyzed for TPH via EPA Method 8015B and ICP Metals via EPA Method 6010C. TPH will be monitored to document the general changes in groundwater petroleum hydrocarbons beyond the COCs. ICP Metals analysis will be conducted to document any changes in dissolved metals within the formation that may have resulted from TEA solution injections.

Extracted groundwater from individual wells will be monitored throughout EBR activities to determine if and at what rate TEA is being distributed between injection and extraction points. Based on groundwater model results, TEA travel times will vary between different injection/extraction well pairs. The following extraction wells are predicted to have a short timeframe (less than two months) to TEA breakthrough and will be monitored on a weekly basis using sulfate field test kits:

- ST012-CZ18
- ST012-CZ19
- ST012-CZ21-EBR
- ST012-UWBZ31
- ST012-LSZ39

In addition, 10% of sulfate field test kit samples will also be analyzed for sulfate offsite via EPA Method 9056A to verify field test results. The remaining 19 extraction wells will be monitored on a biweekly basis for the first 3 months, then will transition to monthly sampling thereafter. Following TEA breakthrough, each extraction well will continue to be sampled and analyzed via the sulfate field test kits on a monthly basis with 10% of samples being sent offsite for sulfate analysis. Modifications to the field test kit/laboratory analysis may be proposed based on the correlations between these methods observed.

5.4 Groundwater Monitoring Well Sampling

Monitoring wells will be used as sampling locations to provide additional dissolved groundwater concentrations data throughout the site. The HASP will include monitoring well headspaces for hazardous hydrogen sulfide concentrations and will also include protocols for purging well casings or other precautions to address potential buildup of hydrogen sulfide concentrations. If excessive hydrogen sulfide concentrations are observed, adjustments to TEA dosing will be considered for future phases.

Perimeter monitoring wells (including those being used as injection points) will continue to be gauged and bailed (if necessary) for LNAPL on a monthly basis for the first six months of EBR activities, and will transition to a quarterly basis thereafter. In addition, all non-active wells will be gauged for LNAPL at the end of the first quarter following startup, and will then be transitioned to gauging on a semiannual basis where LNAPL is not observed. Wells that have observed LNAPL will be considered for more frequent gauging. LNAPL gauging at these wells will help evaluate hydraulic gradients at the site.

As a means to confirm if COCs are being incorporated into biomass and mineralized through bioremediation, SIP sampling and analysis will be conducted at six monitoring wells, two from each of the three hydrostratigraphic zones. One of the monitoring wells from each of the zones is located in the TTZ. These three wells are ST012-CZ2, ST012-UWBZ24, and ST012-LSZ10. The other three wells selected for SIP sampling and analysis are to evaluate LNAPL impact areas that are outside the TTZ. These three perimeter monitoring wells are ST012-CZ20, ST012-UWBZ31, and ST012-LSZ42.

Bio-trap® samplers from Microbial Insights, seeded with synthesized forms of benzene, toluene, ethylbenzene, xylenes, and naphthalene containing carbon isotope ^{13}C, will be placed in each well for approximately one month. The bio-traps will be retrieved from the well and the microbes that grew on the bio-trap will be analyzed to determine if indigenous sulfate reducers are mineralizing and incorporating the COCs into their biomass. As part of SIP analysis, two methods will be used to demonstrate biodegradation of the COC:

- Quantification of ^{13}C enriched phospholipid fatty acids (PLFA), which will indicate incorporation into microbial biomass; and
- Quantification of ^{13}C enriched dissolved inorganic carbon (DIC), which indicates contaminant mineralization.

In addition to the PLFA and DIC analyses conducted on the bio-trap sample; DNA will also be extracted from the samples. The DNA extracts will be analyzed by quantifiable polymerase chain reaction (qPCR) methods to identify and quantify sulfate reducing bacteria.

The deployment of the bio-trap samplers for SIP sampling cannot be conducted in groundwater above 140 degrees Fahrenheit. Additionally, the biotraps should not be deployed until sulfate concentrations have reached the test well locations at concentrations significant enough to support zero-order sulfate reduction. Therefore, the timing of the SIP sampling will be determined in the field and based on feedback from field screening and sulfate/COC groundwater analyses and alternate locations may be selected. Depending on the location of the planned SIP sampling, the duration for cooling, and the travel times for the sulfate SIP sampling and analysis is likely to occur between 6 and 12 months following the start of the EBR sulfate additions and pumping.

5.4.1 Quarterly Groundwater Monitoring

Samples from 10 perimeter monitoring wells and six select MPE wells/Steam Injection Wells within the TTZ will be analyzed for the following on a quarterly basis:

- VOCs (BTEX+N) via EPA Method 8260B
- ICP Metals via EPA Method 6010C
- Sulfate via EPA Method 9056A
- TPH via EPA Method 8015B

5.4.2 Annual Groundwater Monitoring

Annual groundwater monitoring will continue at the site in accordance with the Groundwater Monitoring Work Plan (AMEC, 2013).

5.5 Process Water Sampling

Liquid samples will be collected from the GAC influent and midfluent to monitor for contaminant breakthrough. Liquid samples will be submitted for laboratory analysis for VOCs via EPA Method 8260B on a weekly basis.

Liquid samples will be collected from the GAC effluent to monitor for contaminant breakthrough and to document discharge compliance. Liquid samples will be submitted for laboratory analysis for the following:

- VOCs via EPA Method 8260B on a monthly basis
- Pesticide/polychlorinated biphenyls via EPA SW846 Method 8081/8082 on a monthly basis
- High Resolution Gas Chromatography/High Resolution Mass Spectrometry via EPA Method 1699 (when necessary to verify any pesticides detections that may occur)
- Semi-volatile organics via EPA Method 8270C on a monthly basis

These analyses are subject to change pending updates to the sewer discharge permit.

In addition to chemical analysis, discharge flow rate will be monitored via daily flow meter readings to ensure compliance with the maximum daily discharge flowrate as designated in the sewer discharge permit.

5.6 EBR Reporting

Status and data summaries will be presented as part of the routine Base Realignment and Closure Cleanup Team calls and meetings. Validated data, including laboratory analyses and operational data, will be presented on a quarterly basis with the current quarterly soil vapor extraction progress reports for ST012. Discharge monitoring reports will be submitted as required by the sewer discharge permit. Copies of discharge monitoring reports will be included in the quarterly reports.